POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: SYNCHRONOUS CONTROL OF DTT ECH POLARIZER AND LAUNCHING MIRROR

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The real-time control of Electron Cyclotron Resonance Heating (ECRH) systems is a key feature of modern tokamaks, as it enables both efficient bulk heating and the suppression of plasma instabilities such as Neoclassical Tearing Modes. These systems direct high-power microwave beams to a moving target in the plasma using steerable launching mirrors, for localized plasma heating. Efficient absorption of the microwave by the plasma requires proper polarization of the beams, achieved by controlling the inclination of corrugated polarizing mirrors.For the high-power ECRH system of the Divertor Tokamak Test (DTT), which will include up to 32 1-MW beams, synchronous beam steering and polarization are essential to maximize power absorption and prevent damage to plasma diagnostics and reactor walls. The real-time control of launching and polarizing mirrors must be synergistic, as the optimal polarization direction depends on the launching direction. This necessitates coupled control of launching and polarizing mirrors by a single controller. The objective of this thesis is to research and develop a tokamak-aware real-time control system to synergistically regulate the launching and polarization angles of the multi-beam ECRH system. This will optimize plasma performance and ensure the safe operation of DTT, which will host the most powerful ECRH plant in the world at the time of its completion.
Methods and techniques that will be	The primary focus will be on developing advanced control

developed and used to carry out the research	The primary focus will be on developing advanced control strategies to optimize microwave absorption through the synergistic control of launching and polarizing mirrors. This objective will be achieved by integrating plasma dynamics models with control theory. The candidate will build on state-of-the-art control strategies to create a specialized and efficient algorithm for ECRH systems, leveraging knowledge of tokamak parameters. Given the highly nonlinear nature of the system, nonlinear control techniques are expected to yield better performance, although traditional methods will also be evaluated. As an additional task, the candidate will contribute to the development and experimental validation of models for the actuators of the ECRH system, including the steering launchers mechanism and the polarizing mirrors mechanism.
Educational objectives	The candidate will gain expertise in the field of controlled nuclear fusion and mechatronics. The activity can be broken down in the following intermediate steps (not necessarily in chronological order): •Mechatronic design and modelling of the driving mechanism of ECRH polarizing mirrors for DTT. •Development or improvement of local control loops for launching and polarizing mirrors •Implementation of local control algorithms in DTT specific software and hardware. •Analysis of the absorption response of the plasma for some imposed polarization trajectories, aimed at building a database to be used in the control algorithms. This activity could be carried out on the TCV tokamak, in collaboration with the Swiss Plasma Centre. •Development of high-level control algorithm for launching and polarizing mirrors synergic control. •Implementation of high-level control algorithm in DTT specific software and hardware. As a secondary objective, the PhD candidate will have to take into consideration the foreseen developments in the fusion field (ITER, DEMO, etc.) when choosing among design possibilities, so that the designed logic is relevant

	design possibilities, so that the designed logic is relevant for future fusion machines.
Job opportunities	The PhD candidate will build a significant experience in the field of ECRH systems design and control by working especially with DTT, ISTP-CNR, Eni and other partners of DTT organization. The collaboration with the SPC-EPFL, one of the world's leading research centres in the field of fusion, will enrich the candidate's cultural and personal background. These institutes also represent the main job opportunities. However, fusion research and ECRH design has gained momentum in the last decades and especially in recent years. Many research centres around the world (ITER Organization, EUROfusion, IAEA, UKAEA, IPP, KIT, ENEA, RFX, etc.) need experts in the field. Moreover, as 'fusion electricity' gets closer and closer to becoming reality, private companies (Eni, CFS, etc.) are gaining interest in the subject will be interested in hiring experts.
Composition of the research group	1 Full Professors 2 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Francesco Braghin

Contacts
For questions about scholarship/support phd-dmec@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of

euro 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 750 euro/month- net amount). Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.